ECONOMICS OF ZERO TILLAGE TECHNOLOGY OF WHEAT IN RICE-WHEAT CROPPING SYSTEM OF PUNJAB- PAKISTAN

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ABSTRACT

Zero tillage technology of wheat sowing is a special technique of establishing crops without tillage and seedbed preparation. Wheat is sown through zero tillage drills in the residual moisture to avoid the late sowing and save land preparation cost in rice fields irrigated in mid October. The current study was undertaken in rice growing districts; Sheikhupura, Gujranwala, Hafizabad, Sialkot, Narowal and Lahore of Punjab (Pakistan) to analyse the impact of this technology. The sample size of 162 farmers was determined by using the statistical formula suitable for unknown population. The water saving with zero tillage was not to the extent as it is claimed. There was about 2 acre inches of water saving and water use efficiency was about 13 percent higher in zero tillage as compared to conventional method. Fertilizer use efficiency was 8 percent more in conventional method. Seed rate was more or less the same in both zero tillage and conventional methods. Production Function Analysis suggests more weeds in zero tillage fields and more weedicide cost for its effective control. It was found that conventional method of wheat sowing was better and economically viable as compared to zero tillage, showing the contribution of tillage not only positive but also significant which reflects the importance of tillage operation before sowing in enhancing the yield. The average wheat yield per acre was 6.8 percent lower and net return was 4.3 percent lower in zero tillage as compared with conventional tillage. Average farm size of the sample farmers was 33.8 acres, which indicates that zero tillage has been adopted by relatively large farmers who can afford to sacrify yield by allocating some area to zero tillage to reduce the cost of cultivation. There was no evidence of early sowing of wheat, as it is claimed, enabled by zero tillage.

Key words: Zero tillage; Weedicide; Production Function Analysis.

INTRODUCTION

Zero Tillage Technology is a special technique of establishing crops without tillage and seedbed preparation. The implement used for this purpose is known as Direct Drill or Zero Drill. Under this method irrigation is applied to the rice fields during mid October before harvesting of Rice crop. Wheat is sown through zero tillage drills in the residual moisture to avoid the late sowing and save land preparation cost.

Zero tillage or no-till is not a new crop production concept on a worlds scale. It has been practised for over 40 years in one form or another in UK, USA, Australia, Canada, etc. The rationale of this technology is to increase profits by reducing the tillage cost without proportionally reducing yield. A review of literature on zero tillage indicates that an overwhelming majority of it relates to countries like Canada, USA, Spain, New Zealand and Thailand; where ground realities are not similar to Pakistan. For example crop production in these countries is primarily dependent on rainfall and soil conservation is an important issue. Lower man land ratio and population growth rate and exporting major food items are also major characteristics of these countries. In Pakistan saving of irrigation water/ its efficient use is desirable but pros and cons of strategy used to achieve this objective needs to be carefully assessed. Pakistan is striving to achieve self sufficiency in food. Thus we can not afford any reduction in crop yields and food production. So, adoption of any new technology in agriculture which potentially may result in low production has to be critically analysed.

Wheat is an important staple food crop of Pakistan. Its average yield in Pakistan is far below than the other wheat growing countries, like U.S.A, Mexico, Egypt, etc. Wheat occupies a central position in forming agricultural policies. It contributes 13.7 percent to the value added in agriculture and 3.0 percent to GDP (GOP, 2006).

In rice growing regions where wheat follows rice, its sowing usually gets delayed. In the rice - wheat zone people prefer to grow Basmati rice due to its aroma, higher price, better cooking quality and taste. Basmati rice, being a long duration and late maturing variety, ultimately causes delay in sowing of wheat.

Late planting of wheat after mid November caused significant yield losses. Hence, it necessitates avoiding late sowing of wheat. For in time wheat sowing operations, Zero tillage technology is being introduced in Rice-Wheat system. The main objectives of the study were to analyze the impact of this technology on soil conservation, operational requirements, time of sowing,

water use efficiency, yield, profitability and econometric analysis of zero tillage technology versus existing conventional method of wheat sowing.

MATERIALS AND METHODS

Field Survey: A detailed field survey was conducted to analyse the impact of the o-till technology. The structured and pre-tested questionnaires were used for the survey. The survey was conducted in six districts of rice zone, i.e. Sheikhupura, Gujranwala, Hafizabad, Sialkot, Narowal and Lahore. The sample size was determined by using the statistical formula suitable for unknown population and guessed variability:

$$N = \frac{Z^2 V^2}{e^2}$$

Whereas,

Z = Normal variate at 95.0 percent precision level

V Guessed variability among sampling units i.e 50 percent for maximum sample size

e = Acceptable error i.e 7.7 percent

So,

N = 161.9 say 162

Keeping in view the objectives of the study and the nature of elementary units of study population, the respondents included for interview were those farmers who have been using both the techniques i.e. zero tillage and conventional methods for sowing of wheat, because of having similar resources, type of soil, farming skills etc. In case of non-availability of such respondents, farmers practicing either zero tillage or conventional method were also interviewed.

Economic Analysis: Net benefits and Benefit cost ratio analysis with regard to zero tillage viz a viz conventional method was conducted to determine and compare the economics of 0-till technology with conventional method.

Diagnostic/ Production Function Analysis: A diagnostic analysis has been conducted to assess the contribution of various factors to yield. Since the contribution of zero tillage technology was assessed by making comparison with the conventional wheat cultivation technology, thus two equations were constructed for the regression analysis. So, for zero tillage wheat production technology the functional form was:

$$Y_z = b_o + b_1SD + b_2SR + b_3IR + b_4FT + b_5WP + b_6LB + e$$

Whereas for conventional wheat production technology, the regression equation was as under:

$$Y_c = b_o + b_1CT + b_2SR + b_3IR + b_4FT + b_5WP + b_6LB + e$$

Where

Yz = Yield per acre obtained by the farmers applying zero tillage wheat production technology.

Yc = Yield per acre obtained by the farmers applying conventional wheat production technology.

SD = Per acre cost of sowing using ZT drill.

CT = Cost of tillage per acre for seed bed preparation or preparatory tillage including sowing cost.

SR = Seed rate per acre.

IR = Irrigation measured in inches per acre.

FT = Total nutrients (N+P+K) per acre used for wheat crop.

WP = Cost of Weedicides / pesticides per acre including application of these chemicals.

LB = Per acre cost of labor used to adopt respective wheat production technology.

e = Random error term.

Both the equations were estimated by using Ordinary Least Square (OLS) method. The Statistical Package for Social Scientists (SPSS-10) was used to analyze the data.

RESULTS AND DISCUSSION

Farm Characteristics : Average farm size of the sample farmers was 33.8 acres. About 92 percent of the cultivated area (30.2 acres) was allocated to wheat crop on an average. About 41.4 percent of the wheat area was being cultivated with zero tillage technology, while the remaining was sown under conventional methods i.e. “waddwattar” and “rauni” methods by the sample farmers.

Effect of Zero Tillage: The respondents were asked about the effect of zero- tillage on different parameters.

Seed Germination: Almost 95 percent of the farmers were of the view that wheat seeds sown through zero tillage technology gave early and good germination, while only 4 percent responded it late and poor germination.

Tillering : About 64 percent farmers of the study area briefed that zero tilled wheat plants gave more number of tillers per plant as compared to the conventionally sown wheat, while 24 percent supported decrease in tillering. Almost 12 percent of the respondents told that there was no significant difference.

Crop Stand: More than 84 percent of the farmers responded that zero tillage gave uniform crop stand as compared to 13 percent who claimed that crop stand was somewhat patchy. There were only few cases (3 percent) who told that it was very patchy under zero tillage.

Crop Lodging: The study results show that crop lodging was more or less same in conventionally sown fields and zero tilled fields, as reported by 30 and 27 percent farmers, respectively. Khan *et al* (2002) conducted a study to assess impact of Zero Tillage Wheat Technology in the Rice-Wheat Farming Systems of Punjab. They compared zero till sown wheat with rauni method and

waddwattar method of wheat sowing. Lodging losses were somewhat less (6.2 m/acre) on zero tilled fields as compared to waddwattar (8.33 m/acre) and rauni method (6.7 m / acre).

Soil Health: About 76 percent farmers reported no significant impact on soil fertility, while 24 percent reported increased soil fertility. Majority of the sample respondents (82 percent) told that it did not have any effect on the soils with respect to soil salinity, while 100 percent of the farmers described that it decreased soil erosion. More than 73 percent claimed that soils became compact with the use of zero tillage technology.

Plant Protection: The effect of zero tillage technology with respect to different plant protection factors; weeds, diseases, insect population, were also asked. About 39 percent respondents told that weeds infestation increased in the zero tilled wheat fields against 24 percent who said that weeds decreased while 37 percent told that zero tillage did not have any effect on weeds population. There was no significant effect on diseases and insect population as reported by 96 and 93 percent farmers, respectively. Khan *et al* (2002) have reported that in zero tilled fields there were less than 60% weeds as compared to conventional methods.

Sowing Time: The sowing time was more or less same under both the technologies which leads towards the conclusion that sowing time was not the factor for using the zero tillage technology but it was being applied under the need and desire of the farmers of the area.

Seed Rate: Seed rate was more or less same in both the technologies i.e., zero tillage (46.8 kg/ acre) and conventional method (46.6 kg/acre).

Fertilizer Use Efficiency: Fertilizer use efficiency (FUE) indicates that how efficiently the fertilizer has been used for crop production. It is measured as the ratio of fertilizer applied and crop yield. Results show that the use of fertilizer (NPK – kg per acre) was almost same in zero tillage as well as conventional method (75.6 and 75.7, respectively). However, FUE was more (18.2 Kg of wheat/Kg of NPK) in conventional method of wheat sowing as compared to zero tillage wheat sown (16.8 Kg of wheat/Kg of NPK).

Water Use Efficiency: Water Use Efficiency (WUE) was measured as the ratio of water applied and crop yield. The study findings show that quantity of water applied was higher (9.01 acre inches) in conventional method as compared to zero tillage (6.98 acre inches). The difference was not so higher because in conventional method "waddwattar" was an important method of wheat sowing where no rauni irrigation was used and wheat was sown in residual moisture. The survey results revealed that about 50 percent of the sample farmers used this method of sowing. Water use efficiency was 201.24 kg of wheat per acre inch of water in case of zero tillage and 177.15 kg of wheat per acre inch of water under conventional method.

Crop Yield: The survey results have shown that under zero tillage the average yield was 1238 kg per acre, whereas it was 1328.50 kg per acre in case of conventional method. This shows that crop yield under conventional tillage was 7.3 % higher as compared to zero tillage method. Bhuiyan and Sleque (2004) synthesized the impact of zero or minimum tillage on yield and reported mixed results. Some studies reported more yield under no tillage as compared to conventional and deep tillage while others reported that wheat yield under 0 till were less as compared to conventional and deep tillage. While effect of tillage system on weed biomass showed that mean weeds biomass at 35-40 days after transplanting under no tillage was 1.6 t/ha compared to 0.5 t/ha under conventional tillage in rice crop.

Table 1: Economic Analysis of Wheat Crop under Zero Tillage and Conventional Methods of Wheat Sowing

Items	Zero tillage (Rs./acre)	Conventional (Rs./acre)
Land preparation	-	759
Planting/sowing	379	28
Seed cost	461	495
Irrigation cost	601	843
Fertilizer cost	1887	1910
Plant protection measures	142	130
Harvesting/threshing	1774	1717
Total cost	**5244**	**5882**
Crop yield (Kg /acre)	1238	1328.50
Sale price (Rs./ 40 Kg)	357	357
Gross returns without by product	11035	11857
Value of by product	474	573
Total gross returns	11509	12430
Net benefits	**6265**	**6548**
Benefit-cost ratio	**2.19:1**	**2.11:1**
Additional Returns	**-**	**283(+4.52)***

* Figure in parenthesis indicates percentage.

The Directorate of Adaptive Research conducted a study to evaluate the effect of zero tillage/ direct drilling on wheat yield sown after rice. They used RCBD research design with three replications and four treatments namely a) Zero tillage b) Minimum tillage c) Drill sowing on well prepared soil d) Zero disc tiller drill sowing . The results showed that drill sowing on well prepared soil gave highest yield (4670 kg/ ha) followed by minimum tillage, zero tillage and Zero disc tiller drill sowing. Moreover, the number of stubles/m , number of larvae /m^2 and number of larvae per stubble were highest in zero tillage as compared to the other methods of Wheat sowing (Anonymous, 2003). The findings of Khan *et al* (2002) were also analogous to our study.

Economic Analysis: Under economic analysis, cost of cultivation, net benefits, benefit cost ratio and net margin have been analysed. Benefit-cost ratio based on gross values of both methods indicated that this ratio was slightly higher (2.19:1) in zero tillage as compared to conventional method (2.11:1). But additional return was 4.5 percent more in case of conventional method (Table 1). Anwar *et al.* (2002), reported that net benefit in zero tillage was more as compared to bed planting and waddwattar. Khan *et al.* (2002) also compared zero till sown wheat with rauni method and waddwattar method of wheat sowing. Economic analysis showed that zero tillage method was more profitable as compared to the waddwattar and rauni method.

Diagnostic Analysis: A diagnostic analysis has been made to assess the contribution of various factors to yield.

i) Justification of Variables : The principal objective of the models is to make comparison of wheat production technologies i.e. zero tillage wheat production technology against the conventional wheat production technology. Yield was the dependent variable, while seed rate, irrigation practices, plant protection and labour were common explanatory variables for both the equations. In addition to them for zero tillage technology, cost of using seed drill including use of other implement such as planking or leveler was considered the technology constituting explanatory variable. In conventional tillage, cost of preparatory tillage and seed bed preparation were considered the composite explanatory variable. This variable, applied as proxy for sowing practice leads towards specific technology in respective equation. All the variables were estimated on per acre basis.

ii) Result of the Models : Both the models were regressed by using Ordinary Least Square (OLS) method. The results are presented in Table 2.

Table 2: Regression Results

Item	Conventional Technology		Zero Tillage Technology	
	Coefficient	T-Value	Coefficient	T-Value
Constant	(-) 5.244	-	33.958	-
Tillage Cost**	0.00648	2.441*	(-) 0.0354	(-) 2.737*
Seed Rate	0.287	2.725*	0.147	1.117
Irrigation Water	0.01606	0.197	0.506	2.777*
Fertilizer	0.02298	0.498	0.08676	1.823***
Weedicide	(-) 0.00507	(-) 1.237	0.01524	3.005*
Labour	0.05886	1.416	(-) 0.03758	(-) 1.023
R^2	0.45	-	0.23	-
F-Ratio	10.180	-	7.239	-
N	81	-	151	-

* Significant at 99 percent level of confidence, ** Tillage cost includes land preparation & sowing cost
*** Significant at 90 percent level of confidence, *- Includes only sowing (drilling) cost in Zero Tillage

The estimated co-efficient of determination (R^2) was 0.45 in case of conventional wheat production technology and 0.23 in case of zero tillage wheat production technology. The difference might be attributed to exclusion of tillage variable from the model constructed for zero tillage, whereas, the contribution of this variable to yield was not only positive but also significant. Consequently, it had reduced the variability captured by the independent variables in dependent variables. However, in primary data model, this estimated R^2 leads toward good fit of the equation.

In case of adoption of conventional wheat production technology, the tillage contribution was positive and significant, whereas in case of zero tillage its contribution was negative and significant. This reflects the importance of tillage operation before sowing in wheat production technology in enhancing yield. These results were also supported by relatively higher yield of

wheat attained under conventional method of wheat sowing.

Seed rate also contributed positively and significantly as well in case of conventional wheat production technology. Contrary to that, this input contributed positively but non-significantly in case of zero tillage technology. It could be concluded that tillage operations (in conventional method of cultivation) before sowing improve the germination capacity of the seed leading ultimately to increase in yield.

Contribution of fertilizer use to wheat yield was positive but non significant in conventional wheat production technology, while it was positive and significant at 90 percent level of confidence in zero tillage technology. The estimated fertilizer coefficient shows that 10 percent increase in fertilizer use in zero tillage technology (other things being constant) would increase wheat yield by 0.87 percent.

Use of weedicides contributed positively and highly significantly in case of zero tillage. This gives indication regarding growth of weeds in fields with zero tillage technology. On the other hand, in case of conventional technology this input contributed negatively but non-significantly. The explanation lies in curtailing weeds through "Dab" (eradication of weeds through tillage operations) practice. Thus, incurring expenditure on weedicide after proper tillage may not necessarily result in wheat yield increase. So, the conventional method may result in reduction in plant protection cost as compared to zero tillage technology.

Positive contribution of labour input gave justification of labour use in case of conventional wheat production technology while disguised unemployment was obvious in case of zero tillage technology with negative contribution to yield.

Irrigation input contributed positively and significantly to yield in case of zero tillage. This leads towards appropriate use of this input in case of this crop production technique while in case of conventional technology; this input contributed positively but was non-significant. This leads towards irrational use of this scarce input.

In brief, it could be stated that the conventional wheat production technology was better relative to zero tillage technology, since it affects positively the crop yield by increasing germination capacity of seed associated with poor growth of weeds. So an appropriate use of this input keeping in view its requirements or weed growth may also reduce the cost of production under conventional production technology.

The yield difference against the cost of tillage as was obvious in economic analysis also supports the conventional method to reduce the losses in wheat production at national level.

CONCLUSIONS: The zero-tillage resulted in water saving, better water use efficiency and lower tillage cost. The extent of water saving was not to the extent of what is claimed because about 50% of the sample farmers did not use "rauni" irrigation water under conventional method and they made use of residual moisture/ "wadd water"

The fertilizer use was almost same in both zero tillage and conventional methods. However, fertilizer use efficiency was 8 percent more in conventional method. The seed rate was more or less same in both zero tillage and conventional methods.

Production Function Analysis suggests more weeds in zero tillage fields and more weedicide cost for its effective use. It has also shown the contribution of tillage is not only positive but also significant which reflects the importance of tillage operation before sowing in enhancing the yield.

The average wheat yield with zero tillage was 7.3 percent lower as compared with conventional method. Net return / profitability was 4.5 percent more in conventional method as compared with zero tillage. Thus, the overall economic impact of zero tillage technology was not positive.

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